COASTAL MIXING AND OPTICS MOORED ARRAY

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LONG-TERM GOALS

Our long-term goal is to identify and understand the dominant vertical mixing processes influencing the evolution of the stratification over continental shelves.

OBJECTIVES

We want to understand the dynamics of the surface and bottom boundary layers over continental shelves and how the boundary layers contribute to mixing and the evolution of the stratification. We are particularly interested in the relative contributions of local, one-dimensional mixing processes, such as wind forced mixing, cooling, and tidal mixing versus three-dimensional advective effects.

APPROACH

An array of moorings were deployed at a mid-shelf location in the Mid-Atlantic Bight in August 1996 and recovered in June 1997. The deployment spanned the destruction of the thermal stratification in fall and redevelopment of the stratification in spring. The moored array consisted of a heavily instrumented central site (70-m isobath) and three more lightly instrumented surrounding sites: about

10 km onshore (64-m isobath), 12 km offshore (86-m isobath) and 15 km along isobath toward the east. At each site currents, temperature and conductivity measurements spanned the water column. Additionally, the central site included meteorological measurements to estimate wind stress, surface heat flux and surface buoyancy flux, wave measurements, and a fanbeam ADCP to identify Langmuir circulation.

WORK COMPLETED

Post-calibration and initial processing of the data from over 80 instruments has been completed. Data have been made available to other CMO investigators through the UOP web site and by other means. A data report summarizing the moored observations has been completed (Galbraith et al., 1999). Several data sets important to the project are not described in the report. Surface analysis and flux fields from regional Numerical Weather Prediction models during the field observation period have been archived. Based on comparison with buoy observations, revised maps of momentum, mass and heat flux have been made for the 11-month observing period (Baumgartner and Anderson, 1998). A sonic anemometer system and motion package on the central mooring were used to compute momentum flux using both inertial dissipation and direct covariance methods. The performance of the fanbeam ADCP was assessed and near-surface currents from the ADCP were compared to those from conventional moored sensors (Plueddemann et al., 1998). Historical CTD and mooring observations from the study region have been collected and initial comparisons with CMO data have been made to determine how typical the 1996 and 1997 study period was.

RESULTS

A number of intriguing features were evident from preliminary evaluation of the data. The August 1996-June 1997 deployment captured both the breakdown in fall and revelopment in spring of the stratification. Comparison with historical data indicates water temperatures during the fall of 1996 and the spring of 1997 were typical. However, during most of the winter, December 1996-March 1997, the shelfbreak front extended onshore to at least the 65-m isobath or shallower. Historical data from shipboard CTD casts and the Nantucket Lightship indicate that this was extremely anomalous. Salinities were also anomalously fresh by about 1 psu relative to historical data.

Mean alongshelf flows for fall, winter, and spring are westward between 5 and 10 cm/s with a slight maximum at 10-20 m depth. Seasonal mean cross-shelf flows are offshore at about 6 cm/s near the surface, decreasing to about 1 cm/s at 40 m depth and below. The cause of this mean offshore flow is not known. At subtidal time scales (days to months) the current variability is polarized alongshelf and is correlated with the wind stress. Depth-averaged currents are most highly correlated with the wind stresses oriented about 50 degrees to the left of the flow, which, for the alongshelf flow, corresponds roughly to the large-scale coastline orientation. Near-surface and near-bottom flows are consistent with wind or bottom stress-driven Ekman transports. Cross-shelf correlation scales for subtidal flows, based on CMO and the 1979-80 Nantucket Shoals Flux experiment observations, vary with season. Correlation scales range from 120 km in winter to 60 km in summer for alongshelf flows. For cross-shelf flows, correlation scales are roughly 30-50 km and do not exhibit an obvious seasonal variation. It is unclear what processes determine these scales.

A quantitative comparison of direct covariance momentum flux measurements to bulk aerodynamic and inertial dissipation estimates indicates that both indirect methods underestimate the flux to developing seas (Martin, 1998). A modification to the traditional flux parameterization to account for wave-induced processes, developed as a part of the ONR MBL project, was applied to the inertial-dissipation estimates taken during CMO and significantly improved the agreement between the inertial-dissipation and direct covariance fluxes. This work will be presented at the 2000 Ocean Sciences meeting.

Intercomparison and evaluation of the NCEP regional Numerical Weather Prediction model fields with our buoy observations indicates the Early Eta (EE) model is the most suitable for use in forcing regional ocean modeling in support of CMO. We have removed biases from the EE surface analysis fields, combined them with the 14km NESDIS SST analysis and employed state of the art bulk formulae to generate a set of revised air-sea momentum, mass and heat flux maps for the 11-month observing period over the whole Mid-Atlantic Bight and surrounding regions. The flux map data set spatial and temporal resolution is 29km and 3 hr respectively and is available on a pair of CD-ROMs.

IMPACT/APPLICATIONS

The successful field effort has yielded the most comprehensive set of moored array data on the New England shelf for studying vertical mixing and more generally the shelf dynamics. It should provide a critical context for interpreting other measurements acquired during the Coastal Mixing and Optics field program.

TRANSITIONS

None

RELATED PROJECTS

We anticipate collaborations with many of the other PIs in CMO.

Bottom boundary layers - We have begun collaboration with Shaw, Trowbridge and Williams to determine the dynamics of the bottom boundary layer and the relationship with the interior flow. We are particularly interested in wind forced events in fall and spring that persist for many days after the wind stress has ceased. Preliminary analysis suggests this persistence may be associated with a reduced bottom stress. and its impact on the rest of the water column. We will pursue this in collaboration with Chapman (separate ONR funding) to determine whether there is a shutdown of the bottom stress as suggested in recent modeling work by Chapman and Lentz.

Optics - We have begun some preliminary collaborations with Dickey, Sosik, Boss, and others looking at the influence of strong forcing events (storms and hurricanes) on the optical properties of the water and have provided them with our data to aid in the interpretation of their measurements.

Surface Waves - We are working with Don Thompson and Dave Porter (Johns Hopkins University) to compare surface wave directional spectra from the wave rider buoy to those derived from SAR imagery. Results will be presented at the 2000 Ocean Sciences meeting.

Spatial variability - We anticipate collaborating with Barth and Kosro and with Gawarkiewicz and Pickart (Primer study) to determine the influence of spatial variability in our interpretation of the moored observations. As a first step we have provided the moored current and pressure data to aid in detiding the shipboard ADCP data.

National Weather Prediction model validation: We have been exchanging results from our NWP validation effort with Stan Benjamin, NOAA/ERL Forecast Systems Laboratory, who is developing the Rapid Update Cycle (RUC) regional weather forecasting model for NCEP, and Geoff Demigo with the ETA model run operationally at NCEP.

We continue to collaborate with the MBL PIs (Friehe, Farmer, Smith, Pinkel) in our efforts to incorporate wave-induced forcing in our modeling efforts.

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